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HOW CAN ENERGY-EFFICIENT STRUCTURES COMPETE IN AN

INEFFICIENT ENERGY MARKET

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HOW CAN ENERGY EFFICIENT STRUCTURES COMPETE IN AN INEFFICIENT ENERGY MARKET?

HUMAN SETTLEMENT PATTERNS AND ENERGY CONSUMPTION: AN HISTORICAL PERSPECTIVE

Shelter as a Basic Necessity and Traditional Design Solutions

A common premise is that food, clothing, and shelter comprise the basic necessities of survival. Accepting this basic premise as a departure point, one can hypothesize many interesting relationships among the three necessities as they relate to human physiology and thermal comfort.

The thermal sensation experienced in a given enclosure is a function of several environmental and physiological parameters. Among those parameters are the relative humidity, the relative wind speed, the insulative value of occupant clothing, the occupant activity level, the vapor diffusion rate from the skin, the air temperature (dry bulb), and the mean radiant temperature. The mean radiant temperature is defined as the uniform temperature of black surroundings which will give the same radiant heat loss from a person as the actual case under study. It is helpful to think of mean radiant temperature as an average effective interior surface temperature.(16)

Although the issues of human comfort are complex, one must remember that the relationships between comfort, physiological factors, and environmental conditions (including locally available resources) have provided a dominant force in shaping building architectural styles across the globe for centuries.(11,12) Thus, for example, the shelter design solutions implemented by inhabitants of a hot arid climate have traditionally been quite different from those implemented by inhabitants of a subzero polar region, or a hot humid tropical zone.

In an attempt to provide acceptable levels of thermal comfort, individua's not only adjusted shelter styles and clothing materials but made use of locally available fuel and non-fuel resources for the purposes of heating and cooling to help regulate comfort conditions. Fuel resources included wood, other plant matter, dung, and animal oils while non-fuel resources included wind induced ventilation, stack effect ventilation, radiative and evaporative cooling, solar radiation with thermal wass storage, underground or earth contact habitats, thermal insulation with indigenous materials, and so forth. Thus, there is a large body of historical experience that reinforces the notion of climate adaptive architecture in responding to the basic need of human shelter.(14) Why is it then, that we find ourselves consuming incredibly large amounts of nonrenewable energy to condition and operate the built environment that has emerged in the past several generations in the United States, when in fact, architectural styling and use of indigenous resources had been used to condition structures for centuries?

The Impacts of the Cheap Energy Era (1859-1973)

4. 4

The answer to the above question is attributable to the relationships between our economic system, the pattern of human settlement in the United States, technological development and the initial endowment of abundant fuel resources spread across the United States.

Although the United States has witnessed many changes in the dominance of various energy supplies and the pattern of energy consumption over the past two centuries, (13) the large majority of structures that comprise the current residencial and commercial building stock were constructed during the Post WWI cheap energy era dominated by petroleum and natural gas. Because of the abundance and low cost of these energy resources, buildings were not designed to be energy efficient. Space conditioning, water heating, daylighting and appliance usage costs represented an insignificant portion of total building operating costs, so no incentive existed to increase equipment efficiency or upgrade thermal envelope construction techniques for energy conservation. Indeed, the substitution of energy for conservation and climate responsive design was not even an issue to be dealt with since individuals were making economically rational decisions under the unique set of conditions that prevailed.

Many policies of the federal government between 1930 and 1970 either directly or indirectly contributed to the increased energy use intensity in buildings. The federal interstate highway program facilitated the incredible growth in the automotive and trucking industries and reinforced the trend toward separation of living areas and working areas through induced suburbanization. Highly centralized urban centers were replaced by lower density communities in new growth creas, thereby stimulating the construction of relatively high energy use single family detached residences throughout the country.

In addition, energy policies of the United States were aimed at promoting the development of energy resources to spur economic growth. According to a study by Battelle Pacific Northwest Laboratories (4), "In the years since 1918 the federal government has expended \$123.6 to \$133.7 billion for incentives to stimulate energy production." percent of this total went to oil, 13% to nuclear, 72% to natural gas, 10% to hydro, and 5% to coal. The impact of such incentives has been to promote the use of more energy at lower cost than what might otherwise have been the case. Indirectly this stimulated the development of an energy supply and distribution a, tem that removed responsibility for providing building energy demands away from individuals to more centralized energy producers and distributors. A good example of this transition was the development of a fairly large residential thermosiphon solar water heater market in Florida and Bouthern California in the early 1900's. These systems worked very well but were eventually displaced by water heaters supplied by cheap natural gas through pipeline distribution networks. Largely due to economic reasons, decentralised space conditioning techniques have been replaced by equi; ment that depends upon centrally supplied energy sources.

Coincident with the development of the oil and gas industries was the growth of electric utilities. From the end of World War II to the early 1970's, the cost of providing new generating capacity continually declined in real terms due to more efficient plant designs, government incentives, and economies of scalu realised by constructing larger

units. The demand for consumer durables increased rapidly through the 1950's and 60's and electrical appliances of all types were introduced into the residential sector for entertainment convenience, and labor saving purposes. Electric space heating, water heating, and air conditioning also entered the starketplace, and virtually the entire demand for illumination was provided by incandescent, fluorescent, and neon lighting.

Population growth coupled with low dansity settlement patterns and government policy used to stimulate energy production has left us with a buildings inventory responsible for over 30% of total U.S. energy consumption. Clearly, the potential axists to reduce a sizeable portion of building energy demands through conservation, improved equipment efficiency, and solar energy techniques. However, private sector decisionmakers in the buildings sector have been slow to pursue vigorous energy saving measures. The reasons for this involve a complex set of political, economic, institutional and legal factors that are discussed in the next section.

STRUCTURE OF THE RESIDENTIAL AND COMMERCIAL BUILDINGS SECTOR AND THE ROLE OF EXTERNALITIES

The difficulty of shifting our energy resource base from depletable nonrenewable energy supplies to abundant renewable energy sources lies in the conflict among individuals, private sector businesses, and covernment entities. The nature of these conflicts stems from the fact that each of these groups of decisionmakers has different priorities, responds to different signal existing in the marketplace, and behaves to maintain or improve its own position often at the expense of the position of others.

A factor that further intensifies these conflicts is the overwhelming number of extendities created by the actions of each of the decisionmaking proups: an externality is said to occur when the action of one party has a direct or indirect impact (positive or negative) on the welfare of others. In addition, resource allocation problems are compounded by "market failures." (1)

Residential Sector

Retrofit. The following may serve as an illustrative example. Soymour Sunshine owns a home in a rura! community and is considering an investment to upgrade the envolope of his home through energy conservation measures. In addition, he would like to undertake some solar retrofit with an attached sunspace and a domestic solar hot water heater. However, Mr. Sunshine is reluctant to pursue any of these investments because he pays fairly low energy bills for natural gas and may have trouble financing the necessary home improvement loan due to his other dobts (home mortgage, car, insurance, etc.) and the high cost of borrowed money.

What hr. Sunshing does not realize is that his decision can have a direct impact on his local community and indirectly upon the national economy. If he continues to consume large amounts of natural gas, he is in effect transferring money from his pocket directly to the pocket of his utility (assumed to be apart from the city). The utility in turn generates some jobs within the community with an associated income, but by and large, the majority of the income transfer goes to

holders of the utility's bonds and equity (in the form of debt repayment or return on equity) and to gas suppliers (producers and interstate distributors). If Mr. Sunshine does make the energy conserving investments he will support local contractors who will use local labor and perhaps some locally supplied (but not necessarily produced) products and he will generate additional income (tax free) for himself through fuel savings. In turn, he will respend a portion of these savings within the community and make the loan payments through a local banking establishment (this does not imply that all of the loan funds are generated locally). To the extent that the value of fuel savings exceeds the loan payments, Mr. Sunshine is better off and additional income is generated within the local economy. If these investments were to be made by a large portion of the community residents, a significant direct and indirect spending offect could be generated within the community.

However, as mentioned earlier, the individual may face cheap energy prices in his community. In the case of heating oil, natural gas, and electricity the residential or commercial consumer only pays the average cost of energy. That is, the utility charges the consumer according to a weighed average of the cost of energy supplies that are generated or supplied at various historical costs. Up until 1970, additional increments to electric generating capacity could be supplied at costs below previous increments. In this situation, the average cost of electrical energy declined in real (inflation free) terms. However, after 1970, the economies of scale in large power plant complexes began to reverse, and each additional increment to generating capacity cost more than previous increments. In this situation, average costs which are charged to the consumer include the cheaper generating units built in the past. This means that Mr. Sunshine would be paying electricity rates that are cheaper than if costs were based upon replacement or new marginal generating capacity. In summary, electric utilities are faced with marginal cost requirements, whereas individuals are charged the lower average costs.

Interstate natural gas and heating oil costs also are subject to this disparity. Interstate gas prices are determined from a weighed average of gas supplies, the weights determined by the specific mix of the gas vintages. Vintage refers to the year in which gas came into production from a particular well. Walls of an older vintage are allowed lower maximum cailing prices, whereas newer walls have been allowed higher cailing prices presumably because the cost of production (including discovery) per unit of gas extracted has increased. The same situation exists for domestic petroleum production; however, geograhic inequities largely were eliminated through the antitlements program which equalises the costs of lower priced domestic sources with higher priced imports to refinere in various locations.

The use of average costing implies that the consumer will compare the average costs of a conventional fuel source with the marginal cost of a renewable energy source such as solar. A factor that further aggravates the discrepancy is that the average conventional fuel cost includes many direct and indirect subsidies through R&D programs, depletion allowances, and numerous tax accounting laws. Together these two effects cause consumers to make individual choices that often are at odds with the general welfare of the community, state, or nation as a whole.

Additional uncertainties also discourage homeowners from making potential energy conserving retrofit investments. A partial list would include:

- uncertainty as to the impact of the addition or improvement on the resale value of the home
- uncertainty as to the availability of qualified service personnel in the event of a system malfunction (primarily active solar)
- uncertainty as to the guaranteed right to solar access in an existing residential neighborhood
- uncertainty as to the relative costs and benefits of alternative energy saving capital investments
- uncertainty as to the performance, reliability, and lifetime of certain solar and energy conservation investments.

While these uncertainties are readily identifiable by homeowners and renters, the benefits to society as a whole from such investments are not as apparent. For instance, most individuals would not consider the benefits that accrue from a reduced reliance on foreign sources of petroluem, an improved balance of payments, a stronger U.S. dollar in foreign exchange markets, mitigation of further environmental deterioration due to potential reductions in production of uncertain domestic energy sources, increased employment, stimulation of small husiness opportunities, and so forth. Unless programs are initiated at the local, state, and federal levels to bridge the gap between the benefits and costs of retrofit investments as perceived by individuals on the one hand, and society on the other, the vast energy savings potential in the residential housing stock will remain unrealised for an indefinite period of time.

Mcw Construction. In new construction, the incentive to invest additional dollar amounts in energy conservation techniques (ECT's) must rest with the suppliers of the constructed buildings. The supply side of the construction market includes developers, designers and architects, builders and contractors, and materials suppliers. None of these individuals must pay the cost of operating the completed building, except for situations where the developer is the owner; this may be true for certain multi-unit residential or commercial projects.

Without a series of incentives, mandates, building performance standards, or soning requirements, the impetus to build energy conserving homes must come from the marketplace itself; that is, the builder must perceive a demand for structures that conserve energy but at some additional cost. Passive solar concepts primarily have been developed in the custom home market, where the purchaser usually takes an active role in the design process and is willing to pay the additional expense for passive solar features. No such relationship exists in the speculative market (especially in tract home developments), so the builder must have confidence that solar and energy conservation innovations will be accepted by home-buyers.

With rising energy prices, solar and conservation features in residential housing are beginning to attract attention, but the problems of consimer and supplier uncertainty and indifference remain. Every energy wasteful structure that is built put; an additional economic burden on the initial buyer and subsequent owners (admittedly, for some, this burden is only a minor concern). However, income is draine, out of the local economy, and reliance on conventional non-renewable energy sources is increased. Furthermore, each new energy inefficient building may have a useful life of between 40 and 60 years or perhaps longer. By bypassing the opportunity to integrate conservation, passive, and active solar into new home construction, the only recourse is to retrofit at some later date which is generally less effective and more expensive per Btu saved.

A compounding factor in the new residential construction market is its highly disaggregated structure. Thousands of operative builders construct new residential housing units throughout the country; however, the average builder constructs less than 30 units per year. Competition in such a market drives builders to continue construction of successful designs, and to avoid the risks associated with new concepts such as passive rolar or dual stud wall construction. Innovations in the housing sector usually originate in the custom built market, and if successful, eventually trickle down to the semi-custom and speculative tract home markets. Without the perceived demand or proper incentives, diffusion of energy efficient designs in the new housing market will proceed at a slow rate.

Commercial Sector

The commercial building sector presents another unique set of circumstances. In the residential sector, the builder or general contractor is usually responsible for both the envelope construction and HVAC equipment specification. However, building design in the commercial sector has followed a characteristic pattern that disassociates the architect from the mechanical and electrical engineer.

Buildings as we have designed them in the pas. .ave been designed essentially by four independents: (1) the architect who designs an envelope; (2) the structural engineer who designs a frame to support this envelope, with little concern for what's in the frame; (3) the mechanical engineer who designs the mechanical system which is stuffed into a building; (4) the electrical engineer who designs his electric system and usually the illumination.... These really are designed as four separate encities, pushed all together into a common package.(7)

Unless the roles of each of these independents can be combined at the early stages of the design process, where 90% of all the decisions affecting ultimate energy performance are made, the chances for constructing an energy efficient commercial building are reduced substantially.

Another disincentive to invest in higher first cost energy efficient capital equipment and design is that the building owner may deduct energy costs as an operating expense from gross operating revenues. Although this tax allowance is mitigated to a certain extent

by investment tax credits available for energy conservation and renewable resource measures, it nevertheless provides a disincentive for higher first cost energy efficient design and construction.

PUBLIC SECTOR RESPONSIBILITY AND THE ADEQUACY OF RECENT FEDERAL ENERGY LEGISLATION

Back to Externalities

A major theme of this paper has been that the structure of the buildings sector is such that the cumulative impact of decisions in the private sector is at odds with societal welfare taken as a whole. Because of uncertainties, perceived risks, inefficient pricing signals, imperfect information, other market failures, and the high degree of disaggregation among actors in the residential and commercial building sector, investments in energy conservation and renewable resources are being undertaken at a less than desirable rate. Studies that have delved into the United States energy problem have repeatedly reinforced this point. In particular, these include works by Stobaugh and Yergin (15) (Energy Future: Report of the Energy Project at the Harvard Business School), Resources for the Future and the Ford Foundation (8) (Energy: The Next Twenty Years), Lovins (9) (Soft Energy Paths), Commoner (2,3) (The Poverty of Power and the Politics of Energy), and resolutions set forth by the United Nations Economic Commission for Europe (6) (Human Settlements and Energy). With a consensus as strong as these independent studies seem to indicate, what has been done by the federal government to promote energy efficient building design in the United States?

The National Energy Act (NEA)

The NEA was passed by the Congress on October 15, 1978 after nearly a year and a half of deliberation. The act is composed of five separate bills:

- The National Energy Conservation Policy Act of 1978
- The Energy Tax Act of 1978
- The Public Utilities Regulatory Policy Act of 1978
- The Powerplant and Industrial Fuel Use Act of 1978
- . The Natural Gas Policy Act of 1978

A detailed discussion of the provisions of these acts is not given here, however, major highlights of four of the bills that impact buildings are outlined below.(5)

National Energy Conservation Policy Act

- Utility Conservation Program for Residences
- Weatherization Grants for Low Income Families (\$200 million)
- Solar Energy Loan Program (\$100 million)
- Energy Conservation Loan Program (\$5 Billion)
- Grant Program for Schools and Hospitals (\$900 million)
- Energy Audits for Public Buildings (\$65 million)
- Appliance Efficiency Scandards
- Solar Demonstration Program in Federal Buildings (\$100 million)
- Conservation Requirements for Federal Buildings
- Grante and Standards for energy conservation in Federally assisted housing

- Federally insured loans for conservation improvements in multifamily housing

Energy Tax Act

- Residential Insulation and Conservation Tax Credits (up to \$300 or 15% of the first \$2000 expended)
- Residential Solar Tax Credits (passive solar excluded: income tax credit up to \$2200 covering \$10,000 of expenditures)
- Business Energy Tax Credits
- Denial of Tax Benefits for New Oil & Gas Fired Boilers (denial of investment tax credit and accerelated depreciation)

Public Utilities Regulatory Policy Act

- Rate Design Standards
- Consideration of Rate Design Standards
- Cogeneration Energy Rates

Natural Gas Policy Act

- Price controls on both inter- and intrastate gas
- Deregulation of certain gas
- Incremental Pricing to industrial users

Although many of these provisions will help stimulate energy conscious design in buildings, three points bear discussion.

- a) Natural gas prices are still regulated according to maximum price ceilings by vintage type, with allowances for inflation. Given that the Btu equivalent of imported oil (\$22/Barrel for marker crude) is approximately \$3.75/MMBtu and the highest new gas price is \$1.75/MMBtu plus inflation, a substantial gap exists between the controlled price and world market energy values. This wedge will probably grow over time, thereby further distorting the pricing signals received by building users.
- b) The tax credits allowed for solar and energy conservation are still very low. California has implemented a 55% tax credit which does include passive solar and has been a significant factor in that state's solar commercialization activities.
- c) Low technology solar applications and energy conservation programs are receiving budget cuts in the Department of Energy's programs. Some private sector enthusiasts might applaud this, however, it is disconcerting to see statements in the FY80 United States Federal Budget(10) to the effect that energy conservation tax credits are in place and therefore D.O.E. can relinquish its activities to private sector commercialisation. As stated previously, the preponderance of externalities in the marketplace demands that priority be given to increased incentives, R&D programs, information dissemination, design competition, and other related activities to help stimulate the use of conservation and renewable resources in buildings. The existence of meager tax credits will not, in itself, provide the impetus necessary to realise the substantial energy savings potential in buildings.

HOW CAN ENERGY EFFICIENT STRUCTURES COMPETE IN AN INEFFICIENT ENERGY MARKET?

The only way resources can be efficiently allocated in our market system is if prices of resources, goods, and services properly reflect their true value to society. However, because of (a) imperfections in the pricing mechanisms that currently influence private sector decisionmaking; (b) the difference in planning horizons between individuals and government; and (c) the external benefits that would accrue to society from energy conscious decisionmaking by individuals, it is apparent that there exists a substantial underinvestment in advanced conservation and renewable resource building technologies. Even if domestic energy prices were deregulated to reflect world market prices (now determined by OPEC) it is likely that underinvestment in energy conscious design would still occur. For that reason, the only way that energy conscious design will be implemented to the extent warranted is if a concerted political committment is made to such a program at the federal, state, and local levels. Such a committment is not without preceden. The experiences of Davis and San Diego, California, and the Tennessee Valley Authority exemplify the extent to which energy conservation and renewable resource development can be carried if the political leadership and support is established.

We know the technologies and design solutions for energy efficient buildings are available today and are cost effective. What remains to be seen is whether the political leadership of the United States will fully recognize the sensibility of a concerted conservation and renewable energy resource program for buildings as opposed to continued attempts at increasing energy production to supply an energy inefficient building inventory.

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